(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 June 2002 (06.06.2002)

PCT

(10) International Publication Number
WO 02/45112 A1

(51) International Patent Classification[7]: H01J 7/18, 37/317

(21) International Application Number: PCT/IT01/00582

(22) International Filing Date: 20 November 2001 (20.11.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
MI2000A002558 28 November 2000 (28.11.2000) IT

(71) Applicant *(for all designated States except US)*: **SAES GETTERS S.p.A.** [IT/IT]; Viale Italia, 77, I-20020 Lainate (IT).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **AMIOTTI, Marco** [IT/IT]; Via Ludovico il Moro, 2, I-27029 Vigevano (IT).

(74) Agents: **ADORNO, Silvano** et al.; Società Italiana Brevetti S.p.A., Via Carducci, 8, I-20123 Milano (IT).

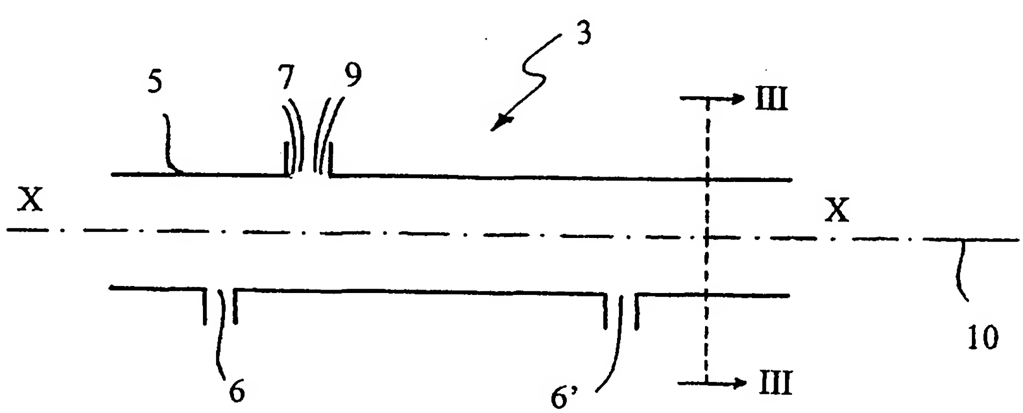
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: ACCELERATION AND FOCALIZATION UNIT WITH IMPROVED VACUUM FOR ION IMPLANTERS



(57) Abstract: It is described an acceleration and focalization unit (3) of ion implanters used in the production of semiconductor devices, comprising a metallic envelope (5) capable of defining the trajectory, around a longitudinal axis (X-X), of an ion beam (10) of a doping material in order to direct this onto a target in a process chamber (4) downstream said unit (3), wherein the inner surface of said envelope is essentially totally coated by a thin layer (8) of a non-evaporable getter material, preferably deposited by sputtering.

WO 02/45112 A1

ACCELERATION AND FOCALIZATION UNIT WITH IMPROVED VACUUM FOR ION IMPLANTERS

The present invention relates to the ion implanters used in the production of semiconductor devices, and in particular to the unit of acceleration and focalization of the beam of doping ions to be implanted in the target, made for instance of silicon.

The ion implantation technique is used with increasing success to introduce controlled amounts of doping materials in semiconductor materials, in particular silicon. Doping species are introduced in gaseous form in an ion source, where the gas is ionized; subsequently the thus formed ions are extracted from the source using an electrode. The useful ions for target bombardment are then selected by means of a suitable magnet that deflects the trajectory of the single ions depending on their atomic mass. The selected ions are finally accelerated and focalized in a specific unit of the apparatus, upstream the process chamber where impact over the target, generally a silicon wafer, takes place. The specific areas of the target to be doped are selected by means of a suitable mask of photoresist material, directly deposited over the wafer.

Despite this technique requires complex and costly apparatuses, it is broadly used in view of the advantages it offers compared to alternative techniques. A first advantage is that ion implantation is characterized by an excellent reproducibility of results, with precision of the hit area and uniformity of depth and profile of implantation, that may be controlled through the energy of ions: typical energy values are comprised between 3 KeV and 2 MeV for implantation depths comprised between 100 Å and 1 μm. Secondly, process temperatures in ion implantation are comprised between ambient temperature and 125 °C, while the alternative technique, in which the dopants are caused to diffuse into the semiconductor substrate through a thermal treatment, requires much higher temperatures, in the range comprised between 900 and 1,200 °C. For selected semiconductor compounds such as GaAs, ion implantation is the only available

method of selective doping, because the temperatures involved in the thermal diffusion technique would cause the melting of the substrate material.

Another important advantage offered by the technique is that no impurities are implanted, thus allowing a precise control of the resulting semiconductor devices. In case gaseous impurities are present in the gas in the ion source, these, once ionized, do not proceed towards the process chamber thanks to the selective action of the ions separating magnet. Moreover, in case non-ionized gaseous impurities enter the acceleration chamber, this latter is contaminated, but the impurities cannot reach the target, coming to collide with a suitable trap provided to collect the neutral particles beam before the ion beam hits the wafer.

The presence of gas phase impurities may however cause indirect reproducibility problems. In any acceleration or deceleration scheme, the ions may change their energy due to impacts with remainder gas particles present on the ion beam trajectory. Also, in these impacts an ion may be neutralized. The resulting neutral species maintains its kinetic energy and continues the travel towards the wafer; anyway, if this happens upstream the acceleration or deceleration zone, as the dopant is neutral, it does not senses the electrical field and its speed remains constant. Both these effects have as a result that some particles hitting the target have an energy different from the required one, thus leading to imprecisions in the amount of implanted material or to deviations of the implanting depth from the desired values, in spite of the continuous controls foreseen to this end.

The problems due to the presence of residual gases can be attenuated through improvement of vacuum throughout the ion beam path. However, the particular geometry and the reduced section of the acceleration and focalization unit hinder pumping, thus making difficult creating and maintaining a high vacuum degree. Besides, the vacuum degree can be degraded by outgassing of the surfaces present in the system. Among possible outgassing sources there are the same walls of the acceleration and focalization unit; the photoresist material present on the wafer, that upon ionic bombardment releases particularly hydrogen and hydrocarbons, with an increasing up to two orders of magnitude of the

pressure in the process chamber and possible back-diffusion of the thus generated gases into the acceleration and focalization unit; and the decomposition of some gases, such as AsH_3 and PH_3, used as carrier gases respectively for As and P, having as a consequence the release of hydrogen, the presence of which is considered particularly detrimental.

The problem thus exists of guaranteeing a good vacuum degree in the acceleration and focalization unit, taking into account that its reduced dimensions decrease the conductance and do not favour the use of pumps for the creation and preservation of a satisfactory vacuum degree.

From the PCT patent application publication WO 97/49109 it is known a pumping device using a non-evaporable getter material to keep a very high vacuum in a chamber defined by a metallic wall subject to outgassing. The non-evaporable material coats the inner surface of said chamber in form of a thin layer, preferably obtained by sputtering. Non-evaporable getter materials are commonly referred to in the technique as NEG materials, definition that will be used in the remainder of the text.

It is an object of the present invention to provide an acceleration and focalization unit for use inside an ion implanter wherein the vacuum is improved not only thanks to a more effective pumping, but also thanks to a reduced contribute of gases released from the material making up said unit of the ion implanter.

This object is obtained with an acceleration and focalization unit of ion implanters for the production of semiconductor devices, comprising a metallic tubular element capable of defining the trajectory around a longitudinal axis of an ion beam of doping material in order to direct this onto a target in a process chamber downstream said unit, characterized in that its inner surface is coated, essentially totally, by a layer of a non-evaporable getter material. In a preferred embodiment of the present invention, the above said thin layer of NEG is obtained by sputtering.

The main advantage of the unit of the invention is that it is thus reduced, in this section of the ion implanter, the number of gaseous molecules that could

modify the ions kinetic energy or neutralise them.

Objects, advantages and characteristics of the unit of the invention for use in ion implanters will result more clearly by the following detailed description of a preferred embodiment thereof, that is given as a non limiting example with reference to the annexed drawings wherein:

- Figure 1 shows a schematic diagram of an ion implanter, as it is used in particular in the production of semiconductor devices;

- Figure 2 shows a preferred embodiment of the acceleration and focalization unit according to the present invention, referred to as numeral 3 in the schematic diagram of figure 1; and

- Figure 3 shows, in enlarged scale, a cross-section view along line III-III of figure 2.

With reference to the figures, the general scheme of an ion implanter for the production of semiconductor devices is represented in figure 1, wherein section 1 represents the ion source, that is, the section where ions are produced.

Section 2 represents the separating magnet, capable of deflecting the neutral particles or ions of materials different from those to be used for doping. In this section the beam 10 of doping ions is formed. Subsequently said beam, comprising essentially only the desired doping ions, is forced to pass through section 3, representing the acceleration and focalization unit of the ion implanter, to finally reach the actual process chamber 4 where the target wafer is housed.

Figure 2 is schematically shows a view along a longitudinal section of the acceleration and focalization unit 3, formed in this embodiment of a tubular element, 5, whose longitudinal axis X-X corresponds to the axis of the ion beam 10. Although schematic, the picture of figure 2 shows a couple of openings 6, 6' and the corresponding pipings provided for connection with external pumping systems (not shown), suitable for preliminarily obtaining vacuum and contributing to its preservation into unit 3 during operation of the ion implanter. By numeral 7 are instead represented the feedthroughs the electrodes (not shown) provided for creating the electrical field that accelerates and focalises beam 10.

According to the present invention, as depicted in the section view of figure

3, the inner wall of unit 3 is coated with a layer 8 of NEG material, preferably deposited through sputtering, as taught in WO 97/49109.

While acceleration and focalization unit 3 is preferably made of a steel tubular element, layer 8 may be formed by any NEG getter element or alloy known in the art.

Most commonly used getter materials comprise the metals titanium and zirconium, their alloys with one or more elements chosen among the transition metals and aluminum, and mixtures among one or more of these alloys with titanium and/or zirconium. Preferred for the present application is the use of NEG materials having a relatively low activation temperature, preferably below 400 °C, such as for instance the titanium-zirconium-vanadium ternary alloys of the above cited published application WO 97/49109.

Layer 8 will generally have a thickness comprised between 0.1 and 10 μm, and preferably comprised between 1 and 5 μm; inside these ranges, said thickness will be generally higher the higher the diameter of unit 3.

Clearly, at any exposure to air of the acceleration and focalization unit, an oxide layer will form onto layer 8 due to the great affinity that NEG materials have towards oxygen. The thickness of such oxide layer can be estimated around 20 Å. With a thickness of 1 μm, this means a concentration of oxygen of about 2% after 10 cycles, as said in WO 97/49109. This "poisoning" degree guarantees that the unit of the invention can be used for several operation cycles of the ion implanter, provided layer 8 is re-activated before any new cycle, bringing it at a temperature for instance of about 400 °C. Activation can be effected for instance by passing current in the layer, taking advantage of the same openings provided already for feedthroughs 7, or through suitable additional feedthroughs 9.

It is finally important to note that in the unit of the invention, comprising a layer of NEG material as described above, the ion beam is directed along axis X-X with only minimal energy losses thanks to the high vacuum degree inside the unit, and that such vacuum degree is maintained even after many hours of operation thanks to the sorption action continuously carried out also on the outgassing products.

CLAIMS

1. Acceleration and focalization unit (3) of ion implanters for the production of semiconductor devices, comprising a metallic tubular element (5) capable of defining the trajectory around a longitudinal axis (X-X) of an ion beam (10) of doping material in order to direct this onto a target in a process chamber (4) downstream said unit (3), characterized in that its inner surface is coated, essentially totally, by a layer (8) of a non-evaporable getter material.
2. Unit according to claim 1, wherein layer (8) is deposited by sputtering.
3. Unit according to claim 2, wherein the thickness of said layer (8) is comprised between 0.1 and 10 µm.
4. Unit according to claim 3, wherein the thickness of said layer (8) is comprised between 1 and 5 µm.
5. Unit according to claim 1, characterized by the fact of comprising connections (6, 6') with external pumping systems.
6. Unit according to claim 1, characterized by the fact of comprising feedthroughs (7) the electrodes creating the electrical field that accelerates and focalises said ion beam (10).
7. Unit according to one or more of the preceding claims, wherein the non-evaporable getter material requires an activation temperature lower than 400 °C.
8. Unit according to claim 7, wherein the non-evaporable getter material is a zirconium-titanium-vanadium alloy.
9. Unit according to one or more of the preceding claims, characterized by the fact of comprising feedthroughs (9) for the passage of current for the activation of the non-evaporable getter material.

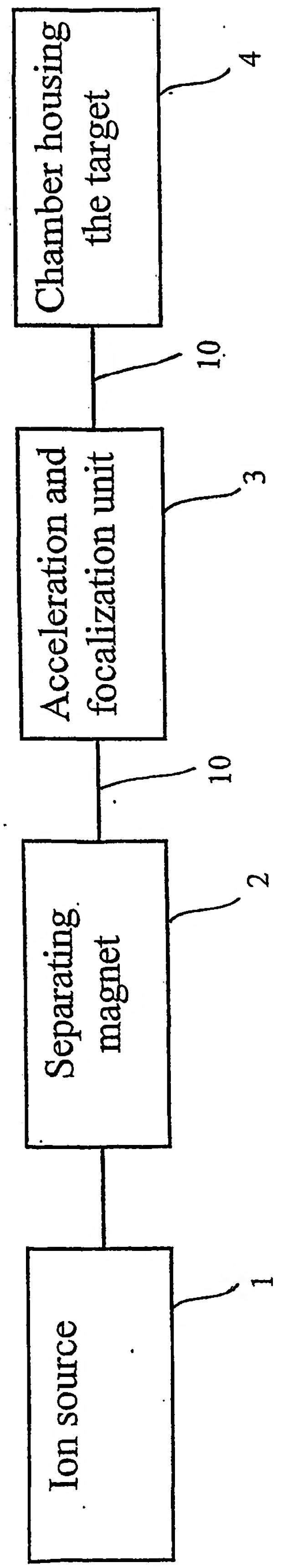


Fig. 1

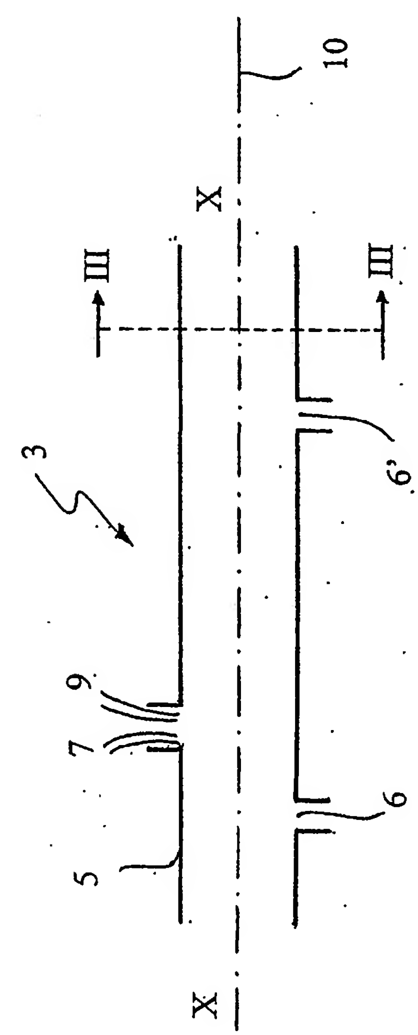


Fig. 2

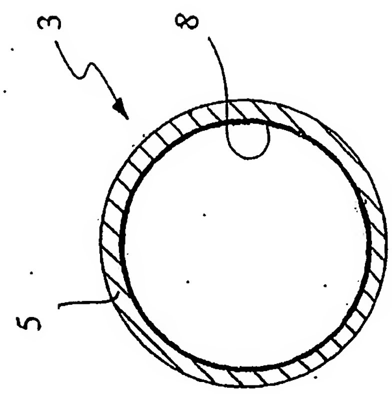


Fig. 3

INTERNATIONAL SEARCH REPORT

Int al Application No
PCT/IT 01/00582

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01J7/18 H01J37/317

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, PAJ, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 2 750 248 A (ORG EUROPEENE DE RECH) 26 December 1997 (1997-12-26) cited in the application the whole document	1,2,7,8
A	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 08, 30 June 1998 (1998-06-30) & JP 10 079237 A (ADVANCED DISPLAY:KK), 24 March 1998 (1998-03-24) abstract	1
A	EP 0 426 277 A (MITSUBISHI ELECTRIC CORP) 8 May 1991 (1991-05-08) the whole document	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 April 2002	18/04/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Schaub, G

INTERNATIONAL SEARCH REPORT

In ıal Application No
PCT/IT 01/00582

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
FR 2750248	A	26-12-1997	FR	2750248 A1	26-12-1997
			AU	3340497 A	07-01-1998
			CA	2258118 A1	24-12-1997
			WO	9749109 A1	24-12-1997
			EP	0906635 A1	07-04-1999
			NO	985927 A	17-12-1998
JP 10079237	A	24-03-1998	NONE		
EP 0426277	A	08-05-1991	JP	3147298 A	24-06-1991
			EP	0426277 A2	08-05-1991
			US	5101167 A	31-03-1992